

Study on biological and ecological characteristics of *Ips subelongatus* Motsch.

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Abstract: *Ips subelongatus* Motschulsky were raised indoors and in the field using fresh baits for study of biological and ecological characteristics during 1992-1994. The life cycle of the pest in Lishu County, Jilin Province was described. The study results indicated that temperature was a main factor affecting the development of *Ips subelongatus*. The initial temperature for development of egg, larva, pupa and adult was 6.1, 8.0, 10.3 and 9.8 °C, respectively. To complete one-generation needs, respectively, 48 d at temperature of 18 °C, 39 d at 20 °C and 33 d at 22 °C. The pest has different number of generations in different area as a result of temperature change. In Jilin Province, it generally has three generations, except that some individuals have 2 generations. The nature enemies for this pest are *Thanasimus substriatus*, *Tomimicobia seitneri* Ruschk., *Coeliodes* sp. etc.

Key words: *Ips subelongatus*; Biological characteristic; Ecological characteristic

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Introduction

Ips subelongatus Motschulsky distributes in Korea, Japan, some areas of Europe, and all China. It is one of major borer pests of Larch plantations in China and causes serious damages. Since 1980s, domestic entomologists have made a great many studies on life history, occurring laws and control methods of this pest and also gained remarkable advance in management and control. This pest is unlikely to be found before rampant occurrence due to the complicatedness of occurring causes and its hidden life and repaid reproduction. Rampant occurrence not only brings about heavy loss in forest but also brings about difficulties in control work. As a result, the control work for this pest lands in a passive position. According to the investigations and reports in 1990s, the occurred area for the stands with 15% trees infested in four forest farms of Lishu County, Jilin Province, reached 20 hm² and that in Mudanjiang, Hejiang, Songhuajiang and Amr forest areas of

Heilongjiang Province reached to 1 027 hm² (Gao 1998). In 1992, "Systematic Control Technique of *Ips subelongatus* Motsch" was set as a key study subject in former Ministry of Forestry of China (presently as National Forestry Bureau). This paper as part of the study subject summarized the studies on life history and the biological and ecological specificity of *Ips subelongatus*.

Study site

One study sites was set at Erlonghu Forest Farm within the jurisdiction of Lishu County, Jilin Province, located at plain area of Liao River (longitude 124° E and latitude 43° N). This area is hilly land of Dahei Mountain, with an altitude of 200 m. The local climate belongs to semi-humidity zone, with annual average temperature of 6 °C, annual precipitation of 500-670 mm, and annual evaporation of 670-1350 mm. The mean temperature in January is -13 °C and that in July is 23.8 °C. The frost-free period is 140-150 d. The area of Larch plantation at and above mid-age is 406.9 hm², of which 175 hm², or 43%, of the plantation were infected by *Ips subelongatus*. A 1.8-hm² fixed plot was set in this plantation. The survey made in 1994 showed that this plot is 22-year-old larch plantation, with an average diameter of 12.3 cm, mean height of 9.8 m and canopy density of 0.3.

Foundation item: This paper is part of key subject of the Ministry of Forestry (formerly) –The Systematic Control Technique of *Ips subelongatus* Motschulsky".

Biography: *GAO Chang-qí (1952-), male, research fellow in Jilin Forestry Academy.

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There are 808 trees in the plot. Of which, the trees on the brink of death were 355 or 44.2%, and 43 or 65% of 66 withered trees were caused to death by the pest, with insect population density of 1.33 emergent holes/100 cm².

The other study site was located at Hongxing Management Sector within the jurisdiction of Dahailin Forestry Bureau, Heilongjiang Province (longitude 128° 56'15" E and latitude 44° 26' N). It is in southeastern slope area of Zhangguancai Mountains, with an average altitude of 445 m. This area belongs to temperate-zone monsoon climate, with an annual average temperature of 2.6 °C, annual precipitation of 556.1 mm, annual evaporation of 993.3 mm. A 40 m×50 m plot was set at a 35-yr-old pure larch plantation with a mean height of 18 m, average DBH of 16 mm and canopy density of 0.4. Pests such as *Lygaeonematus politivadinatus*, *Dendrolimus superans* and *Ips subelongatus* have invaded this plantation for several times since 1980. According to investigations in 1992, the percentage of infected trees by *Ips subelongatus* reached to 15. Its population density was 1.48 emergent holes per 100 cm² on the trunk at above 6 m.

Material and Method

Indoor observation was conducted with raising method of phloem. The raising insects were taken from the overwintering generation in larch plantation. Bait is bark of fresh fallen tree. The bark was put in between two pieces of Polymethyl methacrylate of 30 cm (length) × 20 cm (width) × 0.5 cm (thickness) and fixed with 8 screws. Certain space is kept by inserting some small pieces of wood for easily invading and overthrowing wood scraps and excrement. Bore a 6-mm diameter hole in bark and Polymethyl methacrylate for insect entering. All sides of clamping plate were sealed with gammed paper tape to prevent bark from water loss. A dark box was used for raising the insect.

Fixed and temporary plots were set for outdoor observation. The bait trees were barked for observation every two days. Developing stages, survival rate, natural enemy and so on were recorded. The life table of this insect was compiled. Besides written records, video recording and camera shooting were also used for recording. Statistic analysis was conducted on computer.

Observation results

Morphological feature

Adult

The color of just emerged adult changes gradually from milky white to light yellow, yellow, dark brown

and black-brown, and its elytrum have changes from soft to hard. Body length of adult is in range of 4.4-6.0 mm. Length of elytron is 1.5 times the pronotum and 1.6 times the two wings' width. There are four independent teeth along each side of wing covers, the first tooth is not very thin, and the distance between the 2nd tooth and 3rd tooth is maximum. *Ips subelongatus* has no tumors in center of the lower part of forehead.

Larva

The aging larva is 4.2-6.5 mm in body length, with bending, more folds and bristles on back and presents in milky white. Its head shows gray yellow and yellow brown. Its forehead is in triangle type with a pair of antennas on it. There is a pair of aeropyles on prothorax and each abdominal segment from first to eighth.

Pupa

Body length of pupa is 4.1-6.0 mm, colored in milky white. Feet and wings fold on abdomen. There are two spine-processus on the end of 9th abdomere.

Egg

Egg is in ellipse form, 1.1 mm in long diameter and 0.7 mm in short diameter, colored in milky white, a little transparent, and has luster.

Life cycle

Ips subelongatus has three generations a year in Lishu County, Jilin Province, and some individuals have two generations a year. The overwintering adults begin to fly in April and look for host to bore. Oviposition starts in May and averagely lasts 9 days. In early May larvae can be seen and the larva period averages 19 d. Pupa period starts in early June and lasts 10 d. Adults emerge in the middle June. In late June the first generation adults come out from tree bark. From emergence to the time being out of the bark, the adults take a replenishing nutrition period of 12 d. It is about 50 d to finish this generation.

The first-sister generation adults begin to lay eggs in the end of June with an average oviposition period of 5 d. Larva period is about 13 d and it starts in early July. Pupa period averages 8 d and starts in middle July. The new adults of second generation can be seen in late July. The adult replenishes nutrition in the bark for about 10 d, then, it comes out. The completion of second generation needs about 36 d.

The adults of second-sister generation begin to lay eggs in early August and average oviposition period is about 5 d. The larva of this generation can be seen in middle August. Pupa period starts in late August and averages 8 d. With changes of temperature,

some pupa may overwinter within the bark. In early September the third generation adults come out of the bark after 16-day replenishing nutrition. Up to early October, the adults for third generation begin to overwinter beneath litter or soil layers, with only few of them overwintering in tree bark. The life cycle for third generation is about 42 d.

In late May of next year, the overwintered adults begin to lay egg second time. First-sister generation adults could be seen in late June to early June. The first-sister generation adults begin to lay eggs in late

July. Second-sister generation adults emerge in late August to early September, and they get into overwintering in late Sept. to early Oct.

Ips subelongatus has a seriously overlapping phenomenon on generations. From middle May to late August, the eggs, larvae, pupae and adults of this insect can be seen in forest. The temperatures for development of egg, larva, pupa and adults are 6.1, 8.0, 10.3 and 9.8°C. The time for occurrence of different generations see Table 1.

Table 1. Life cycle of *Ips subelongatus*

Lishu County 1991													
Item		April			May			June			July		
		Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
Temperature, °C		2.2	10.5	9.8	13.0	18.5	19.5	18.4	21.3	20.3	23.8	23.1	23.0
Humidity, %		44	33	43	62	33	34	73	74	76	71	83	83
First oviposition for overwintered adults	First generation	+	+	+	+	+			O	O			
	Second generation						—	—	#	#	#	#	#
	Third Generation												#
Second Oviposition for overwintered adults	First generation				+	+				O			
	Second generation						—	—	O	#	#	#	#
Item		August			September			October			December		
Temperature, °C		Early	Mid	Late	Early	Mid	Late	Early	Mid	Late	Early	Mid	Late
Humidity, %		23.4	21.1	20.9	19.7	17.8	11.4	10.2	8.9	3.11			
First oviposition for overwintered adults	First Generation	#	#	#	#	#	#	+	+	+			
	Second Generation	#	#	#	#	#	#	+	+	+			
	Third Generation	#			—	—	—	(—)	(—)	(—)			
Second Oviposition for overwintered adults	First Generation	#	#	#	#	#	#	+	+	+			
	Second generation	—	—	O	O	O	(O)	(O)	(O)	(O)			

Note: + means adult; (—) overwintering larva; (O) overwintering pupa; • egg; —larva; O pupa; # new larva.

Characteristics of biology

Temperature has great effect on egg development. Egg period is about 9 days in May, while in late June to mid-August it is about 5 days. Unfertilized eggs couldn't hatch.

Newly hatched larva feeds towards the direction cross main tunnel. Its feeding way is basically like that of adult. Larva makes a turn of 180 degree, push the debris out of bore by its head, which is a little different from the way taken by adult, and then turns back to original place and makes feeding. The development of larva is affected by temperature. Development period of larva is about 19 d in May, while in July to August it is only about 13 d.

The grown larva pupates at end of sub-tunnel inside of host bark. The pupa case shows ellipse. The grown larva stops feeding by 3 days prior to pupation. Pupation period is 8 d.

After supplement of nourishment for 10-16 d inside tree bark, the adult bites a hole of emergence and creeps out. Generally, the male adult firstly fly out, looks for host, builds mating room, and releases pheromone to attract the female for mating. Three females and one male could be commonly found in a bore. They could mate many times during the oviposition period. The amount of pheromone reduces with increase of mating times. Male and female mate 30 s by face-to-face and tail connecting. After mating, the female begins to bite and build main tunnel and lay eggs in ready-made egg cells along both sides of main tunnel, with one egg in each cell.

In late October, adults leave tree stem for litter or earth layer to overwinter. The adults who develop slowly, or the ones who has just developed to larva or pupa state may overwinter in tree bark. The overwintered adults begin to fly in April of next year. They seek host, build tunnel, mate and lay eggs. An overwintered female adult could lay 30-120 eggs, with an average of 40.2 eggs. The oviposition stage is about 20 d, which may varies with temperature change. After finishing first stage oviposition, the female continues to bore forward for 1 cm, stay 3-4 d in main tunnel, and then, bite a hole to creep out of the tun-

nel for supplement of nourishment, build up another tunnel for second stage oviposition and reproduce next sister-generation. The oviposition amount in sister-generation has a remarkable reduction, with an average of 25 eggs. The female adults die in main tunnel after oviposition.

Based on investigation of 50 invading holes, it is found that the tunnels of *Ips subelongatus* are mostly compound vertical-tunnels, with one upper and tow down. The total length of main tunnel is usually 9.0-35.2 cm; averaging to 21.33 cm. Branching width (including extending length of sub-tunnel) is 8.35 cm. Each single main tunnel is 4.7-19.7 cm long. Mating room is located at both sides of the tunnel. The size of egg cell is just for placing the head of female. The interval distance of egg cases is 1.4-6.0 mm. Sub-tunnels, about 7.3-21 cm long, are located at two sides of main tunnel. Pupa case and emerging hole are at the end of sub-tunnel. The size of pupa case is 7.82 mm × 4.34 mm. Very few individuals make single vertical-tunnel and star-type tunnel.

Ecological characteristics

Effect of temperature on development of the insect

In climate factors, temperature is a decisive factor for occurrence and development speed of *Ips subelongatus* in the distributed area. For example, in Lishu County, the overwintered adults could lay egg in early May, while in Dedu County, oviposition time put off to late May. As temperature influence, *Ips subelongatus* has one generation per year in Heihe District, Heilongjiang Province, with very few individuals having two generations, while it has two generations a year in Hejiang District. The effect of temperature on development of the insect was analyzed and the results were shown in Table 2 and Table 3.

From Table 2 and Table 3, it is seen that the developmental period of all stages of the insect in early spring is longer than that in mid summer, since the temperature in early spring is lower than that in mid-summer.

Table 2. Experiencing days of each development stage of *Ips subelongatus* under different temperatures in field

Generation	Item	Egg	Larva	Pupa	Adult	Sum
First	Date	May 4-12	May 13-31	June 1-10	June 11-22	
	Average temperature °C		19	18.4	21.3	
	Days of development		19	10	12	50
Second	Date	June 29-July 3	July 4-16	July 17-24	July 25-August 3	
	Average temperature °C	22.0	23.1	23.5	23.2	
	Days of development	5	13	8	10	50
Third	Date	August 8-12	August 13-25	Aug. 26-Sep. 2	Sept. 3-18	
	Average temperature °C	21.1	21.0	20.3	18.75	
	Days of development	5	14	9	16	44

Table 3. Experiencing days of each development stage of *Ips subelongatus* under different indoor temperatures.

Temperature °C	Egg	Larva	Pupa	Adult	Sum
18	7	17.2	9.6	13.8	48
20	6	14.3	7.6	11.2	39
22	5.2	12.2	6.3	9.4	33

Effect of water content of bark on development of the insect

The water content of tree bark, as a basic condition, decides whether the insect could survive or not. When the water content of tree bark is over 168% or less than 50%, *Ips subelongatus* did not invade the host (Guo 1989). Lower water content of bark may result in shrivelled eggs, and the invaded adults may withdraw from the host if the water content is too high. Indoor raising result indicated that hatching rate of egg was 89%, and the survival rate of larva and pupa was 78% and 90.1% respectively, at temperature in range of 15-23 °C and relative humidity of 79%. Field raising result indicated that when the temperature averaged 13 to 23 °C and humidity 33% to 76%, the hatching rate of egg, survival rate of larva and the survival rate of pupa was 74.6%, 61.3% and 78.1% respectively, which were lower than those of the indoor, as a result of that the water loss of baits in field is quicker than indoor baits.

Occurrence of the insect and growing status of trees

Ips subelongatus is a secondary invading pest of larch, mainly invading fallen trunk, wind-broken tree, stump and weakly growing trees, but it could also invade healthy trees during outbreak period. The outbreak of this pest usually occurs in the larch stands with bad sanitary conditions and weak growth, where there are many fallen trunks, branches and stumps in the stands. Removal of invaded trees, fallen trunks, treatment of over-high stumps, and carrying out sanitary cutting are effective measures for control of this pest.

Nature enemy

Thanasimus substriatus feeds on the eggs, pupae

and pupae of *Ips subelongatus*. It can eat 4 young larvae per day. *Tomimicobia seitneri* Ruschk is parasite on overwintering adults of *Ips subelongatus*, with 11% of parasitic rate. *Coeliodes* sp. has 28% parasitic rate on larvae of this pest. *Coeliodes* sp. has two generation a year. When the parasitized larvae develop to 3rd stage, the small *Coeliodes* sp. comes out of the larva body and pupates at the end of sub-tunnel. After emerging in early July, *Coeliodes* sp. seeks the young larvae of *Ips subelongatus* to lay eggs. It overwinters as pupa and emerges in mid-June of next year. Insectivore mite feeds on 20% eggs of *Ips subelongatus* and could also parasitize on the tip of elytrum of adults. The life-table of *Ips subelongatus* studied by Zhang Runsheng in 1994-1995 revealed that the population control rate by nature enemies was about 40%.

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